Trans-Pacific Demonstrations
North American Network Engineering

JUSTSAP Conference

November 2000

Mark Foster

NASA Research and Education Network

TPD North American Network Engineering

- Background
- Network Architecture
- Network Testing
- Obstacles and Challenges
- Conclusions

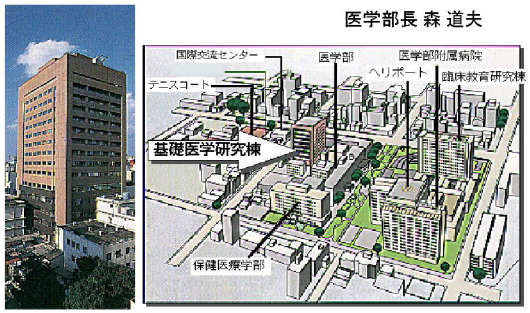
Background: Participants

- **Visible Human: Key End Sites**

National Library of Medicine

基礎医学研究棟落成式

医学部長 森 道夫



Sapporo Medical University

Background: Participants

- **Remote Astronomy: Key End Sites**

Mt. Wilson

Communications Research Laboratory

University of Maryland College Park

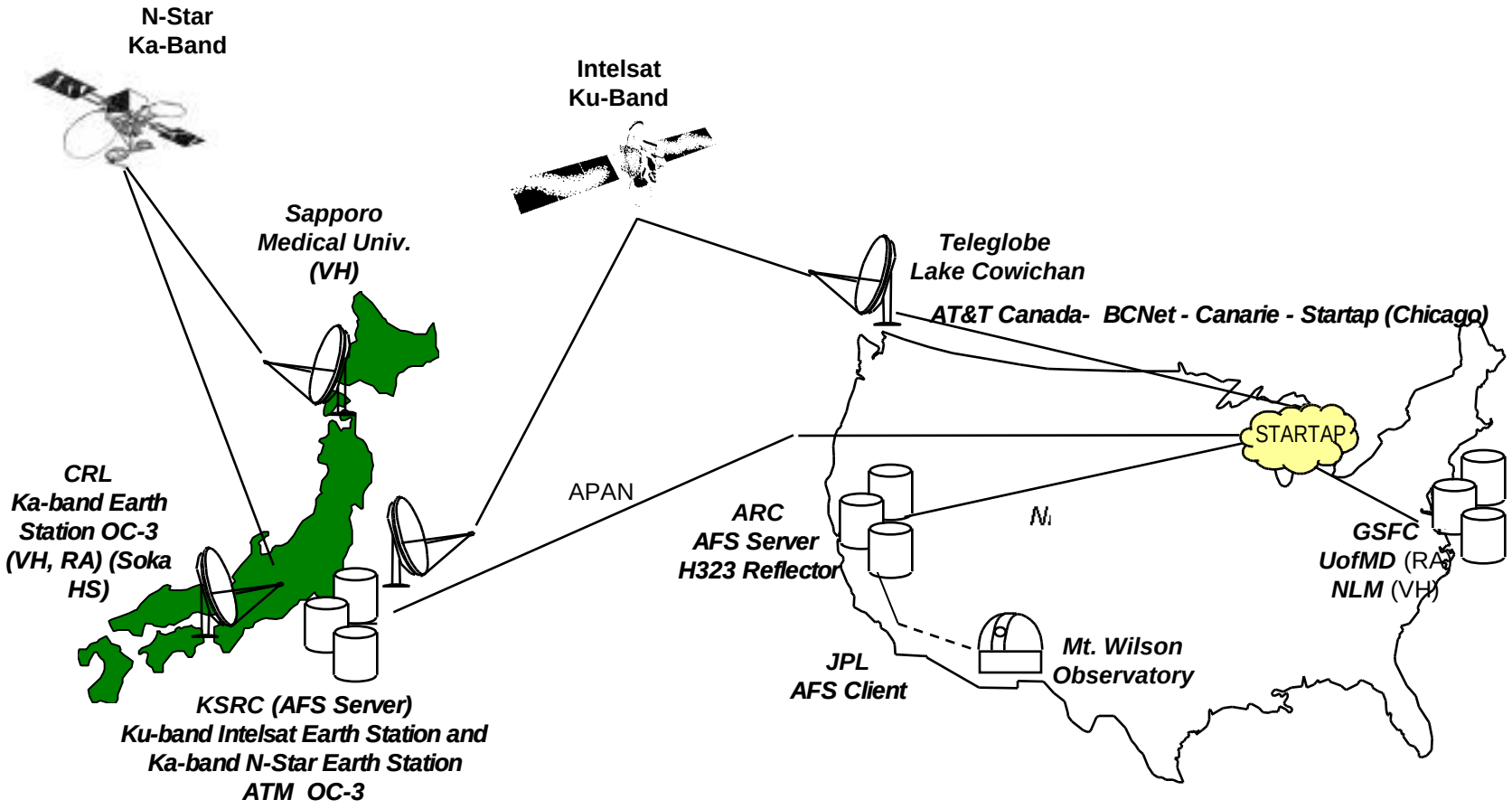
NASA Ames Research Center

NASA Jet Propulsion Laboratory

Network Architecture

- **Key Sites**
  - ***North America:*** **NASA Goddard Space Flight Center, STARTAP, BC Gigapop, Lake Cowichan**
  - ***Japan:*** **Tokyo Exchange Point, Kashima Space Research Center**
- **Satellite Providers**
  - ***Intelsat, N-Star***
- **WAN Transit Providers**
  - **NASA (NISN/NREN), CA*Net3, Teleglobe, AT&T Canada**
  - **APAN/TransPAC, (Japan) IMnet**

Trans-Pacific Connections



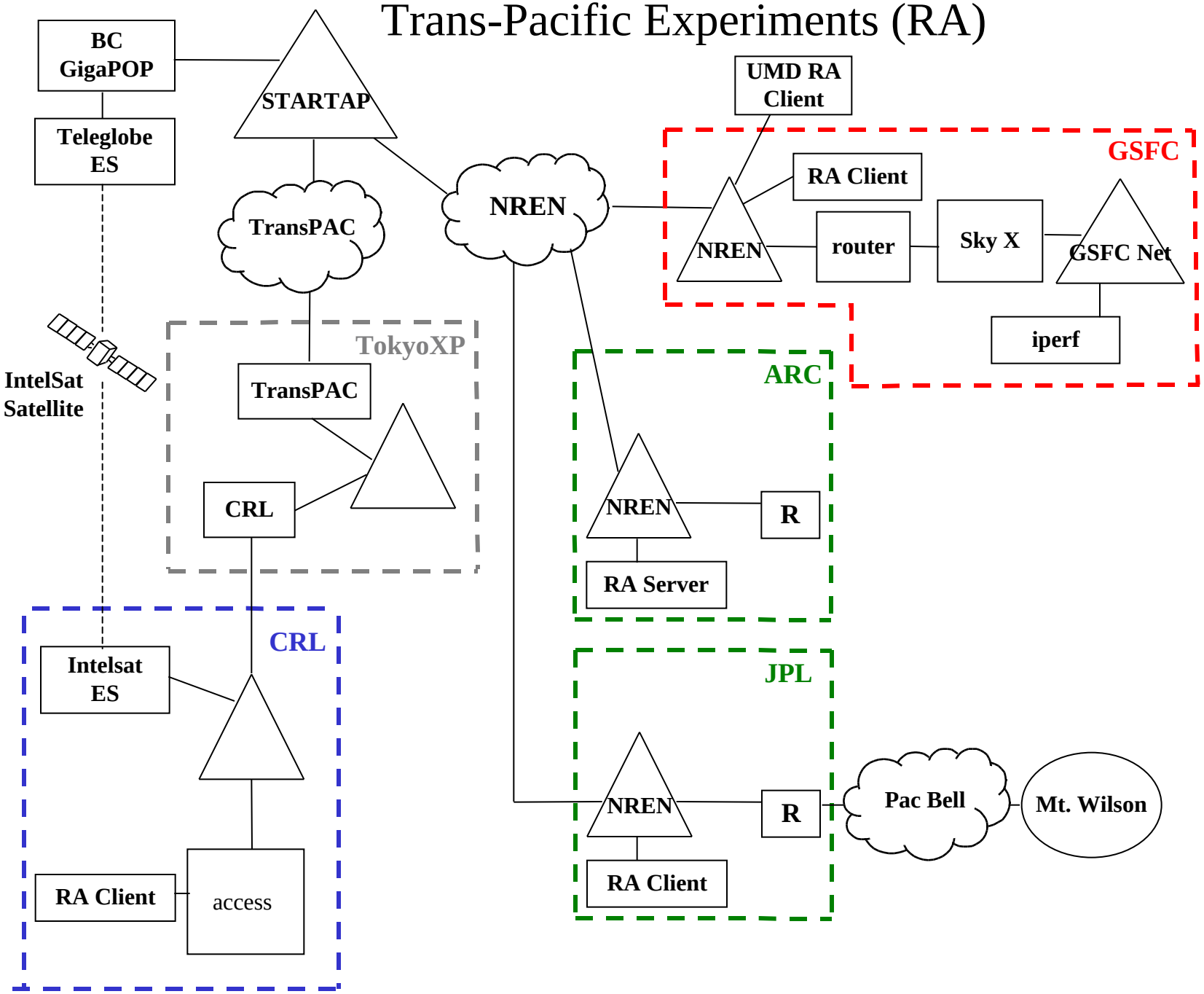
Network Architecture, Cont'd.

- **Key Features**
  - *Parallel paths between U.S. and Japan*
  - *SkyX translation (TCP support over satellite links)*
- **Preparation and Operation**
  - *Phase 1 (functional application testing): terrestrial only (APAN/TransPAC)*
  - *Phase 2 (operational): conducted over Intelsat; additionally for VH over N-Star*

Network Testing

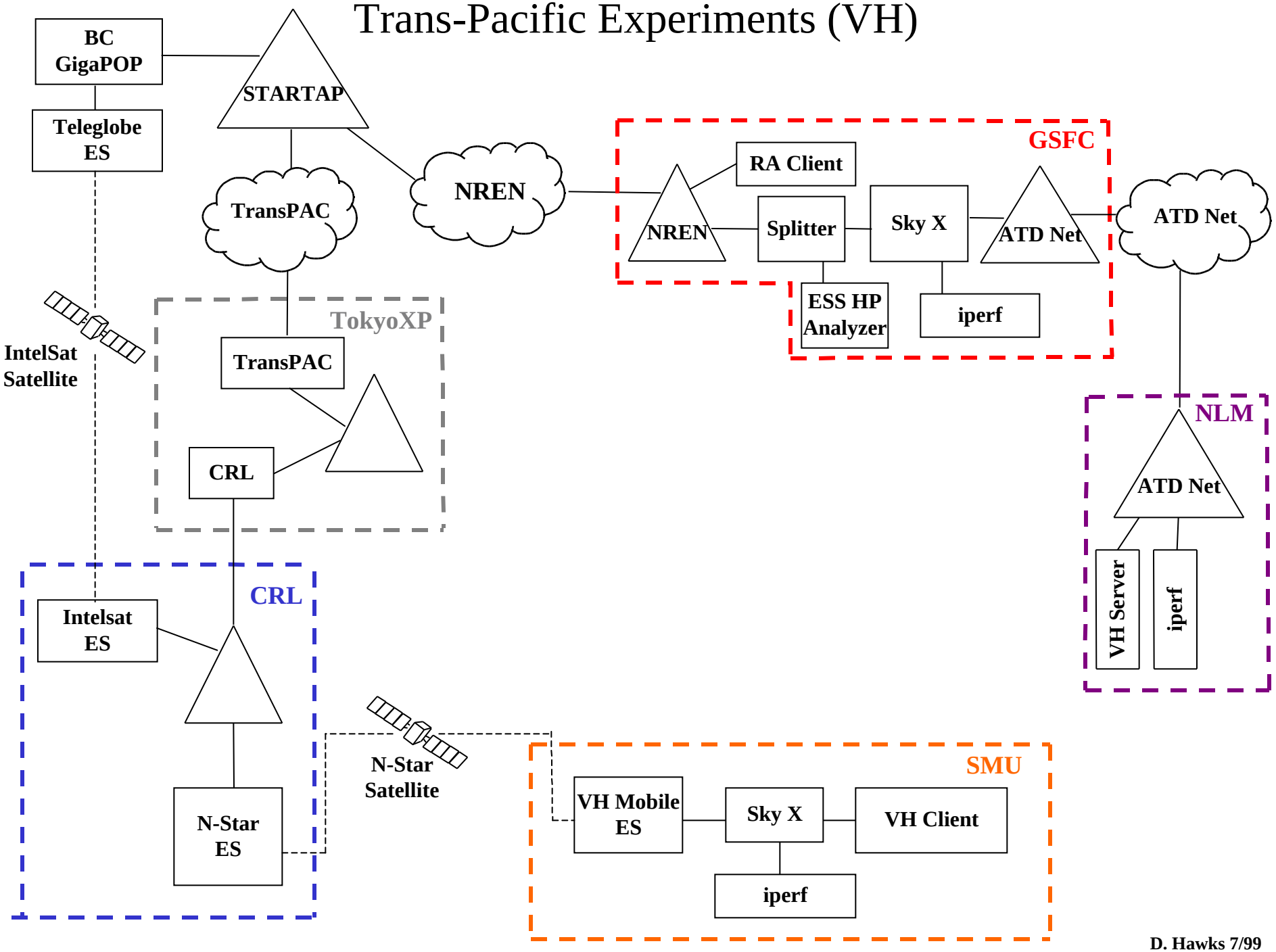
- **Reachability, roundtrip time, loss rate, hop count, path symmetry, throughput**
  - ***Ping tests every 4 hours, aggregated results made available on Web site***
    - Delay over Trans-Pacific link of key interest (both APAN and Intelsat)
  - ***Traceroute every 4 hours to examine path symmetry, route stability***
  - ***Iperf to measure TCP and UDP throughput***
- **Primary test paths**
  - ***National Library of Medicine <> Sapporo Medical University***
  - ***Ames Research Center <> Mount Wilson Observatory***
  - ***Ames Research Center <> Communications Research Lab***
  - ***Ames Research Center <> Jet Propulsion Lab***
  - ***Ames Research Center <> University of Maryland***

Trans-Pacific Experiments (RA)



D. Hawks 7/99

Trans-Pacific Experiments (VH)



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Network Test Results

Path	Via	Throughput (Mb/s TCP/UDP)	RTT (ms)	Jitter (ms)	# Hops	Loss Rate (%)	Sym-metric?
NLM-SMU	TransPAC	1.2/1.3	192		17	0	Y
	Intelsat	15.3/32.1	1131		15	0	Y
SMU-NLM	TransPAC	1.2/1.3	192		16	0	
	Intelsat	11.9/32.0	1131				Y
ARC-CRL	TransPAC	0.26/9.0				0.1	Y
	Intelsat	0.27/10.0				0.5	Y
CRL-ARC	TransPAC	1.9/9.1					
	Intelsat	0.76/11.1					Y
ARC-JPL	NREN	NA/10.0*			7	0	
JPL-ARC	NREN	NA/NA	NA	NA	NA	NA	
ARC-UMD	NREN	3.9/7.7*	58		7	0	Y
UMD-ARC	NREN	6.2/NA	58		7	0	
MWO-ARC	NISN	1.2/1.3	19			0	Y
ARC-MWO	NISN	1.2/1.3	19			0	

Network Test Results

Path	Via	Throughput (Mbps TCP)	Throughput (Mbps UDP)	RTT (ms)	# Hops	Loss Rate (%)	Symmetric
NLM-SMU	TransPAC	1.2	1.3	192	17	0	Y
	Intelsat	15.3	32.1	1131	15	0	Y
SMU-NLM	TransPAC	1.2	1.3	192	16	0	
	Intelsat	11.9	32.0	1131			Y
ARC-CRL	TransPAC	0.26	9.0			0.1	Y
	Intelsat	0.27	10.0			0.5	Y
CRL-ARC	TransPAC	1.9	9.1				
	Intelsat	0.76	11.1				Y
ARC-JPL	NREN	NA	10.0*		7	0	
JPL-ARC	NREN	NA	NA	NA	NA	NA	
ARC-UMD	NREN	3.9	7.7*	58	7	0	Y
UMD-ARC	NREN	6.2	/NA	58	7	0	
MWO-ARC	NISN	1.2	1.3	19		0	Y
ARC-MWO	NISN	1.2	1.3	19		0	

Network Test Results, Cont'd.

- **TCP measurements and window size of 64 KB**
  - *Maximum for systems that do not support window scaling*
- **SkyX processing used for NLM <> SMU over Intelsat (200 - 800 Kbps without SkyX)**
- **Notable: poor TCP throughput over satellite link**
  - *AT&T ATM circuit provisioned for DS-3; all other links were 45 Mbps or above*
  - *Speculation on cell drop because of ATM rate limiting*

Laboratory Testing

- Testbed with ATM rate-limiting parameters configured identical to operational network
- TCP tests were run on testbed
- Default parameters provided 32 Mbps UDP, 200 - 600 Kbps TCP
- Optimal parameters provided equivalent UDP, TCP throughput

	Default parameters	Optimal parameters
SCR	52K cps (20 Mbps)	
PCR	104K cps (40 Mbps)	
MBR	250 ms	1 second
CDVT	250 μsec	1000 μsec

Obstacles & Challenges

- **Propagation delay (RTT)**
- **ATM PVC parameters**
  - *Careful tuning required*
- **IP routing**
  - *More organizations means more complexity, particularly when supporting multiple paths*
- **TCP window sizes**
  - *Some operating systems do not support larger sizes*
- **NFS/AFS performance tuning**
- **Some challenges were anticipated**
  - *SkyX helped for the TCP window size and RTT*
- **Lack of test equipment at all locations**
  - *Characterization and problem diagnosis harder*
- **Determination of requirements and communication of those requirements**

Conclusions

- **Coordination of connectivity for large-scale projects takes significant effort**
  - ***Effort increases as the number of organizations increases***
  - ***Satellite adds some complexity, but layer2 connectivity and handling time zone differences proved to be the most significant***
- **Not all modern computing platforms are able to handle high speed long distance communication**
- **Some objectives of original project unmet; the experience will be beneficial to similar projects**

Acknowledgements

NREN would like to thank the following for their support of network setup and engineering tests:

- *GSFC* – Paul Lang, Kevin Kranacs, Bill Fink, Pat Gary
- *NLM* – Mike Gill, Jerry Moran, Jules Aronson, Ivette Reategui
- *JPL* – Eddie Hsu, Chaw-Kwei Hung, Claudia de Luna
- *CRL* – Naoto Kadowaki, Nozomu Nishinaga, Naoko Yoshimura
- *UMD* – Patrick Shopbell, Dan Magorian
- *SMU* – Haruyuki Tatsumi, Hiroki Nogawa
- *MWO* – Steve Golden, Gil Clark
- *BC GigaPOP* – Don McWilliam, Mike Bluett
- *Teleglobe* – Normand Forget, Soster Souffrant, George Attia
- *CA*net3* – Rene Hatem, Thomas Tam
- *NISN/CSOC* – Michael Whisenant, Terry Leger
- *GRC* – Will Ivancic
- *IMnet* – Mitsutoshi Wada
- *STAR TAP* – Doug Pearson
- *Intelsat* - Joe Jankowski